SPECIAL CONTRIBUTIONS.

CLIMATOLOGY OF COSTA RICA.

Communicated by H. PITTIER, Director, Physical Geographic Institute.

TABLE 1.—*Hourly observations at the Observatory, San Jose de Costa Rica, during May, 1901.*

Hours.	Pressure.		Temperature.		Relative humidity.		Rainfall.		
	Observed, 1901.	Normal, 1889-1900.	Observed, 1901.	Normal, 1889-1900.	Observed, 1901.	Normal, 1889-1900.	Observed, 1901.	Normal, 1889-1900.	Duration, 1901.
	660+ Mm.	660+ Mm.	° C.	° C.	%	%	Mm.	Mm.	Hrs.
1 a. m	3.90	3.84	17.44	17.92	88	91	0.0	0.8	0.00
2 a. m	3.57	3.47	17.13	17.67	88	91	0.0	0.7	0.00
3 a. m	3.38	3.23	16.76	17.50	89	90	0.0	1.8	0.00
4 a. m	3.37	3.21	16.42	17.34	90	90	0.0	0.6	0.00
5 a. m	3.52	3.44	16.33	17.18	89	90	0.0	0.5	0.00
6 a. m	3.78	3.79	16.43	17.10	88	90	0.0	0.7	0.00
7 a. m	4.17	4.21	18.39	18.88	76	84	0.0	0.2	0.00
8 a. m	4.34	4.52	21.76	21.00	64	76	0.0	0.5	0.00
9 a. m	4.46	4.66	23.77	22.88	57	70	0.0	0.6	0.00
10 a. m	4.40	4.56	25.77	24.55	52	64	0.0	0.1	0.00
11 a. m	4.12	4.35	26.72	25.37	51	63	0.0	0.5	0.00
12 m	3.79	3.92	26.80	25.83	53	63	1.7	1.4	0.63
1 p. m	3.32	3.30	26.83	25.67	54	63	31.7	4.6	1.33
2 p. m	2.97	2.81	25.27	24.51	61	68	17.6	18.5	2.83
3 p. m	2.73	2.55	23.48	23.06	68	74	31.5	21.5	2.80
4 p. m	2.79	2.52	22.05	21.74	75	78	28.1	40.4	4.58
5 p. m	2.96	2.72	21.09	20.87	78	83	4.5	36.4	1.58
6 p. m	3.38	3.19	20.36	20.06	81	86	8.3	34.2	1.42
7 p. m	3.76	3.65	19.86	19.39	85	88	4.2	26.6	2.06
8 p. m	4.12	4.03	19.47	19.08	85	89	1.1	20.1	1.33
9 p. m	4.35	4.35	19.00	18.82	87	90	0.1	11.7	1.00
10 p. m	4.48	4.64	18.64	18.40	88	90	0.1	5.5	0.67
11 p. m	4.40	4.60	18.16	18.32	88	91	0.0	3.4	0.00
Midnight	4.21	4.29	17.73	18.10	88	91	0.0	1.6	0.00
Mean	3.76	663.75	20.89	20.46	76	81	......	......	......
Minimum	661.20	660.43	12.8	11.9	......	......	......	......	......
Maximum	665.90	667.12	31.4	32.5	......	......	24.1*	40.4	......
Total	......	......	......	......	......	......	128.9	232.3	19.57

* Thus in the manuscript.

REMARKS.—The barometer is 1,169 meters above sea level. Readings are corrected for gravity, temperature, and instrumental error. The dry and wet bulb thermometers are 1.5 meters above ground and corrected for instrumental errors. The hourly readings for pressure, wet and dry bulb thermometers, are obtained by means of Richard registering instruments, checked by direct observations every three hours from 7 a. m. to 10 p. m. The hourly rainfall is as given by Hottinger's self-register, checked once a day. The standard rain gage is 1.5 meters above ground. In the Costa Rican system the San Jose local time is used, which is $0^h\ 36^m\ 13.3^s$ slower than seventy-fifth meridian time.

TABLE 2.

Time.	Sunshine.		Cloudiness observed, 1901.	Temperature of the soil at depth of—				
	Observed, 1901.	Normal, 1889-1900.		0.15 m.	0.30 m.	0.60 m.	1.20 m.	3.00 m.
	Hours.	Hours.	%	° C.	° C.	° C.	° C.	° C.
7 a. m	13.58	12.61	50	22.40	22.74	23.00	21.94	21.67
8 a. m	23.90	19.43						
9 a. m	26.84	21.07						
10 a. m	24.60	21.53	50	23.04	22.90	23.04	21.97	....
11 a. m	23.59	19.91						
12 m	21.04	16.85						
1 p. m	15.54	15.27	70	23.83	23.27	22.75	21.97	....
2 p. m	14.55	14.21						
3 p. m	9.02	10.72						
4 p. m	4.75	7.01	90	23.77	23.30	22.72	21.92	....
5 p. m	3.09	4.77						
6 p. m	0.42	2.01						
7 p. m	....	....	70	23.51	23.24	23.02	21.92	....
8 p. m	....	....						
9 p. m	....	....						
10 p. m	....	....	50	23.23	23.15	23.01	21.92	....
11 p. m	....	....						
Midnight	....	....						
Mean	....	....	60	23.30	23.27	22.94	21.95	21.67
Total	180.92	165.28	....	....	....	....	....	....

Notes on the weather.—Up to the 17th the weather was dry, very hot, with daily threats of rain from the northeast in the afternoon. The 18th was the first day of real invierno or rainy season, but even afterwards there were dry and close days, quite unusual at this time of the year. In the surroundings of San Jose, coffee began again flowering after the first rainshower of the 18th, this being the latest flowering noted since 1888. On the Atlantic slope, the drought was very unusual and very marked on the coast belt.

Notes on earthquakes.—May 4, $5^h\ 20^m$ p. m., slight tremor. May 5, $4^h\ 31^m$ a. m., very light shock.

Evaporation.—During the daytime, 81.9; during the nighttime, 19.5.

TABLE 3.—*Rainfall at stations in Costa Rica*, 1901.

Stations.	January.		February.		March.		April.		May.	
	Amount.	No. rainy days.	Amount.	No. rainy days.	Amount.	No. rainy days.	Amount.	No. rainy days.	Amount.	No. rainy days.
	Mm.		Mm.		Mm.		Mm.		Mm.	
1. Boca Banano	265	17	98	11	278	14	219	16	92	8
2. Limon	304	19	72	9	214	15	193	12	96	7
3. Swamp Mouth	......	......	131	10	241	13	302	11	......	......
4. Zent	......	......	......	......	......	......	246	14	30	7
5. Gute Hoffnung	411	15	106	14	224	12	235	11	74	8
6. Siquirres	406	10	45	4	160	8	......	......	54	7
7. Guapiles	340	13	114	8	......	......	221	7	159	7
8. Sarapiqui	......	......	......	......	......	......	243	19	164	19
9. San Carlos	301	19	67	14	96	13	110	13	92	9
10. Las Lomas	521	16	131	10	181	14	66	4	123	4
11. Peralta	335	11	65	4	190	13	150	9	152	11
12. Turrialba	......	......	......	......	......	......	85	10	51	9
13. Juan Vinas	159	14	40	10	12	6	50	8	34	5
14. Santiago	......	......	......	......	......	......	66	9	34	11
15. Paraiso	......	......	......	......	......	......	......	......	......	......
16. San Rafael C	......	......	......	......	......	......	......	......	......	......
17. Tres Rios	2	1	5	1	0	0	2	1	92	12
18. S. Francisco G	......	......	......	......	......	......	......	......	187	12
19. San Jose	7	2	9	1	26	1	1	1	129	10
20. La Verbena	4	2	9	1	24	1	1	1	45	12
21. Alajuela	......	......	5	2	6	2	1	1	381	17
22. San Isidro Alajuela	0	0	1	1	......	......	8	1	311	24
23. Nuestro Amo	......	......	11	2	50	3	0	0	310	20
24. Sipurio	......	......	......	......	149	12	229	13	102	13

MONTHLY STATEMENT OF AVERAGE WEATHER CONDITIONS FOR MAY.

By Prof. E. B. GARRIOTT.

The following statements are based on average weather conditions for May, as determined by long series of observations. As the weather of any given May does not conform strictly to the average conditions, the statements can not be considered as forecasts.

Along the steamer routes of the North Atlantic Ocean severe storms are less frequent than during April. The average southern limit of arctic ice near Newfoundland and the Grand Banks extends southward to about the forty-first parallel. May is one of the months of greatest fog frequency from the Banks of Newfoundland to the United States coast.

The wet season in the West Indies and the typhoon season in the Philippine Islands begin in May.

In the Pacific coast districts of the United States the wet season is nearing its end. In the middle and northern Plateau regions there is a slight increase in the amount of rainfall as compared with April. In Arizona May is one of the driest months of the year. From the Rocky Mountains to the Mississippi River there is a general increase in rainfall leading to the June maximum. East of the Mississippi River May is usually a month of frequent rains, and in the middle and southern districts of the country, from the Rocky Mountains to the Atlantic coast, severe thunderstorms are not uncommon. On the Great Lakes the severer storms of May advance from the middle-eastern slope of the Rocky Mountains. These storms average about two a month, and their approach is indicated by rapidly falling barometer and east to southeast winds. After the passage of the center of a storm the wind shifts to northwest with rising barometer.

In May the regions in which agricultural products are subject to damage by frost are usually confined to the extreme upper Missouri, and Red River of the North valleys, and the Rocky Mountain and Plateau regions from central New Mexico and the Texas panhandle northward.

SOME CAUSES OF THE VARIABILITY OF EARTHSHINE.

By H. H. KIMBALL.

(Read before the Astronomical and Physical Society of Toronto, June, 1901.)

When we observe the new moon shortly after sunset we are generally able to distinguish the outline of the whole moon, and the dark part is usually of a delicate green tint, or copper color. At the hour of sunset the sun is shining upon the half of the world that is west of us, while the eastern half is shrouded in darkness and night. Between us and the sun in the west is the moon, whose western half is illumined by the sun, but whose eastern half receives no direct sunlight, and is in darkness like the earth, except that its dark half may receive considerable light from the bright half of the earth. This so-called earthshine may vary considerably with the condition of the earth's surface and atmosphere. When the bright half of the earth is covered with snow or cloud it undoubtedly reflects more sunlight than a continent of forest and vegetation, and much more than an ocean of water, and on such occasions the dark half of the moon might be expected to be unusually bright. It is not often that we are able to collect data as to the condition of the atmosphere or of the earth's surface sufficient to satisfactorily explain the variations in the brightness of the dark side of the old moon when seen in the arms of the new.

Mr. G. E. Lumsden, President of the Toronto Astronomical and Physical Society, has requested any information that may be obtainable relative to the condition of the bright half of the earth at 6 or 7 p. m., eastern time, March 22, 1901, which corresponds to 11 p. m. or midnight, Greenwich time, or noon in the middle of the Pacific Ocean. By means of the data given in the Nautical Almanac we ascertain that at Greenwich midnight the sun was in the zenith at about longitude 180°, latitude 0° 40′ north, and the moon was in the zenith at about longitude 132° west, latitude 15° 7′ north. We have therefore prepared, in Chart X, an orthographic projection of the western half of the earth upon the horizon of a point whose zenith is about midway between the sun and moon at this time, namely, latitude 10° north, longitude 160° west. It would have been more correct to have made the projection with the moon in the zenith, but the results would not have differed appreciably from those here given.

Mr. Lumsden writes as follows:

> On the night of the 22d of March the moon, owing to earthshine, was so bright that a member of the Astronomical Society called me up by telephone, and asked me to make observations with the naked eye and an opera glass, with a view to comparison on other occasions. Indeed, I and other members who took the matter up in the course of the evening were surprised at the brilliant illumination, which enabled us to identify, even with the naked eye, certain well known lunar formations. On thinking the matter over, it occurred to me that this brilliancy might have been due to reflection from a very large area of clouded surface, which possibly at the time was true of the western American Continent and the Pacific Ocean, inasmuch as, shortly after midnight, the weather changed, and was succeeded by cloudy skies which lasted for some little time.

Referring to Chart X, and having in mind the positions of the sun and moon at the time specified above, we see that the sun illuminated the half of the globe from longitude 90° west, across the Pacific to 90° east, while the moon could only receive light from the earth's equatorial region as far west as longitude 138° east. Furthermore, while the sun illumined the earth practically from pole to pole, the moon received no light from the antartic regions beyond latitude 75° south. The illumined portion of the earth from which the moon received light, may therefore roughly be stated to lie between latitude 75° south and the North Pole, and longitudes 90° west and 138° east; and Chart X shows that it embraces practically the whole of the Pacific Ocean, the eastern portions of Australia, Japan, and Siberia, and the larger portion of North America—an area that does not differ sensibly, in character or extent, from the normal reflecting surface when the moon is two or three days old, and observed at about 7 p. m. from Toronto.

According to Bond,[1] the quantity of light received at any point by reflection from a surface may be represented by the equation

$$di' = \theta \frac{\mu i}{4\pi} \frac{dp'}{\Delta^2}, \tag{1}$$

in which di' may represent the quantity of light received by reflection from the earth upon an element of the moon's surface, ds', projected as dp' upon a plane perpendicular to a line joining the earth and moon; Δ the distance between the earth and moon; μ the albedo of the earth's surface; i the amount of light received by the earth from the sun, which we may assume to be a constant; θ a coefficient that varies with the reflecting properties of the reflecting surface. The value of θ is 1 for a polished sphere, 2 for a flat opaque disc reflecting equally in all directions on the side of the hemisphere toward which it is exposed, 4 for a flat disc in which the quantity of light reflected to any point is proportional to the apparent area of the disc as seen from that point, etc., assuming that the incident rays are parallel and perpendicular. For any given surface, however, this coefficient may be considered a constant, and its exact value does not concern us in the present investigation, since we have to do only with the variables of the above equation. We therefore obtain from equation (1) for the total light received at the moon by reflection from the earth the following expression, in which C is a constant:

$$i' = C \frac{\mu}{\Delta^2} \tag{2}$$

Similarly, for the light reflected back from the moon to a point on the earth, by substituting (2) for i in (1), we obtain the following equation:

$$di'' = \theta' C \frac{\mu}{\Delta^2} \frac{dp'' \mu'}{4\pi \Delta^2}, \tag{3}$$

in which di'' represents the quantity of light received upon an element of the surface of the earth, projected as dp'' upon a surface perpendicular to a line connecting the earth and moon; θ' is a constant, as in equation (1), and μ' is the albedo for the moon. This albedo must also be a constant, since in the absence of an atmosphere we can not conceive of any variation in the reflecting power of the moon's surface, except the inappreciable variation due to the fact that by reason of libration a slightly different hemisphere is presented to us from time to time.

Our final equation for the quantity of earthshine observed on the moon from a point on the earth will therefore have the following form:

[1] George P. Bond, On the light of the moon and of the planet Jupiter. Memoirs American Academy of Arts and Sciences. 1861. Vol. VIII, p. 233.